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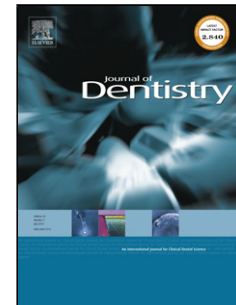
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The relationship between oral health and oral health related quality of life among elderly people in United Kingdom

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Abstract

Objectives: To identify the determinants of OHRQoL among older people in the United Kingdom. **Methods:** A subset of elderly (≥ 65 year) participants from the UK Adult Dental Health Survey 2009 data was used. OHRQoL was assessed by means of the OHIP-14 additive score. The number of missing teeth; presence of active caries, dental pain, root caries, tooth wear, periodontal pockets $> 4\text{mm}$, loss of attachment $> 9\text{mm}$; having PUFA > 0 (presence of severely decayed teeth with visible pulpal involvement, ulceration caused by dislocated tooth fragments, fistula and abscess); and wearing a denture were used as predictor variables. Age, gender, marital status, education level, occupation and presence of any long standing illness were used as control variables. Multivariate zero-inflated Poisson regression analysis was performed using R-project statistical software. **Results:** A total of 1277 elderly participants were included. The weighted mean(SE) OHIP-14 score of these participants was 2.95 (0.17). Having active caries (IRR=1.37, CI=1.25;1.50), PUFA > 0 (IRR=1.17, CI=1.05;1.31), dental pain (IRR=1.34, CI=1.20;1.50), and wearing dentures (IRR=1.30, CI=1.17;1.44), were significantly positively associated with OHIP-14 score. Having periodontal pockets $> 4\text{mm}$, at least one bleeding site, and anterior tooth wear were not significantly associated with the OHIP-14 score. **Conclusion:** Whereas previous research has suggested a moderate relationship between oral disease and quality of life in this large scale survey of older adults, the presence of active caries and the presence of one or more of the PUFA indicators are associated with impaired oral health related quality of life in older adults, but not indicators of periodontal status. The implication of this is that whilst focussing on prevention of disease, there is an ongoing need for oral health screening and treatment in this group.

Keywords

Elderly, Oral Health Related Quality of Life, National survey, Dental Caries, PUFA, dental pain

Introduction

With global changes in life expectancy, there has been a growth in the population aged over 65 years, particularly in developed countries [1]. Not only is the proportion of the population who fall into groups historically termed ‘the elderly’ (aged over 65 years) increasing, there is also an increase in the proportion who enter this age group who retain their health and functioning. This is true as much in oral health as it is in general health [2]. The World Health Organisation has identified that this will bring new challenges in maintaining the dentition and oral health of those aged over 65 years [2]. However little is known about how these trends will impact upon the lived experience of older people.

Oral Health-Related Quality of Life (OHRQoL) is a multidimensional construct that corresponds to the impact of oral health or diseases on an individual’s daily functioning, well-being or overall quality of life [3, 4]. Almost all measures of OHRQoL have been founded on Locker’s conceptualization of the impact of oral disease based on the WHO model of health [5]. This model states that there are five consequences of oral disease: impairment, functional limitation, pain/discomfort, disability, and handicap. Further the model proposes that these domains are sequentially related such that Impairment (structural abnormality e.g. caries) leads to functional limitation (restrictions in body functions, e.g., difficulty chewing) and pain/discomfort (self-reported physical and psychological symptoms), which, in turn, leads to disability (limitations in performing daily activities, such as an unsatisfactory diet) and disability may then lead to handicap (social disadvantage, such as social isolation). Impairment and functional limitation may also lead directly to handicap. Locker’s model has typically been viewed as a framework for understanding oral health rather than as a scientific model to be empirically validated but implicit in the model is the assumption that there is a relationship between poor oral health and impaired quality of life. This assumption has been questioned, and it would appear that any relationship is moderate [6-9], while Locker argued that the concept of quality of life is broader than clinical health and therefore such measures should not be expected to show high correlations [10]. However, understanding which aspects of oral disease have the greatest impact on well

bring may help to identify priorities for prevention and treatment. The aim of the present study is to explore the relationship between oral health status and oral health related quality of life in older adults in the United Kingdom.

Methods

Data from Adult Dental Health Survey (ADHS), United Kingdom 2009 was used in this study. The 2009 ADHS is the fifth in a series of national dental surveys that have been carried out every ten years since 1968. The 2009 survey covers the adult population in England, Wales and Northern Ireland, but excludes Scotland which decided not to participate in the 2009 survey. A two-stage cluster sample was used for the survey comprising of 253 primary sampling units (PSU) across England and Wales, and a further 15 PSUs in Northern Ireland. Each PSU consisted of two postcode sectors with 25 addresses sampled from each, giving a total sample of 13,400 addresses. Of these 12,054 were eligible for inclusion (1,346 ineligible were unoccupied households, business addresses, care homes etc.). Of the 12,054 eligible households, 7,233 participated (60% household response rate), while the remaining 3,895 households refused to participate or were non-contactable ($n = 455$) or other non-response ($n = 471$). Within the 7,233 households there were 13,509 adults who were asked to participate in the survey - of these 11,382 participated (84%). A questionnaire based interview and clinical examination were used to get a picture of the dental health of the adult population. From these 13,509 interviewed participants, a clinical examination was completed for 6469 individuals for oral health and function including dental caries experience. Detailed information about the UK ADHS is available elsewhere [11]. A subset of the 1277 elderly individuals aged 65 years or older was included in this study.

OHRQoL was measured using the 14-item Oral Health Impact Profile (OHIP-14). The OHIP-14 has good reliability, validity, and precision [12]. The OHIP-14 measures the frequency of occurrence oral impacts in seven conceptual domain, two questions for each dimension namely; functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social

disability and handicap [12]. Ratings are made on a 5-point Likert scale: 0 = never; 1 = hardly ever; 2 = occasionally; 3 = fairly often; 4 = very often/every day. Summary OHIP-14 scores were calculated by summing ordinal values for 14 items. Higher OHIP-14 scores indicate worse and lower scores indicate better oral health-related quality of life.

Sociodemographic factors (Age, gender and marital status) socioeconomic status (education level, occupation and index for multiple deprivation), oral health status (active caries, periodontal pocket, number of missing teeth, gingival bleeding, root caries, anterior tooth wear), smoking status and general health (having any systemic problem, self-reported general health) were used as explanatory variables for the prediction of OHIP-14 and its domains. Sociodemographic factors, socioeconomic status, smoking status and general health variables were measured through self-report in the questionnaire. Education level was coded as “no qualification, below degree, and degree/above degree”. Occupation was measured using National Statistics Socio-economic Classification (NSSEC) and categorised as “professionals, intermediate, manual and unemployed”. Index of multiple deprivation (IMD), measures the relative deprivation of the people on a decile scale, it was recoded into quintiles with the lowest quintile representing the wealthiest participants and the highest quintile for the poorest. Clinical examination was performed in order to determine the oral health status. Findings from the examination were dichotomized into “no or yes” for the oral health status variables; having active caries, at least one pocket $\geq 4\text{mm}$, at least one bleeding site, at least one PUFA score, pain related to teeth, active root caries and anterior tooth wear. The number of missing teeth was categorised into five categories “0-5, 6-11, 12-17, 18-23 and 24-32. Smoking status was measured as “never, past and current smoker”. Self-reported general health measures the self-perception towards their general health and was measured as “very good/good, fair and poor/very poor”. The presence of a systemic health problem was dichotomised as “no or yes”.

All statistical analyses for this study were performed using R- project statistical software. The ADHS 2009 examination survey weights were used to account for the unequal probability sampling and geographical clustering of the data. The mean and standard error (se) of the Oral Health Impact Profile-14 (OHIP-14) were explored. Total OHIP-14 was a continuous count variable (ranging from 0 to 56) with a high prevalence of zero values. Therefore, Zero-inflated Poisson was used in bivariate and multi-variable regression models for analysing OHIP-14 as an outcome variable. A series of sequential bivariate and multivariate Zero Inflated Poisson (ZIP) models were used to estimate the associations between explanatory variables and OHRQoL, by calculating incidence rate ratios (IRR) for the non-zero OHIP-14 scores and odds ratios (OR) of having no event (score of zero in the outcome). Bivariate models were used to measure the association between OHIP-14 and explanatory variables. Multivariate ZIP models were used to measure the association of each explanatory variable with OHIP-14 after adjusting other variables. Domain scores were ranged from 0 to 8, however, there were relatively few non-zero values in the domain variables. Therefore, values on these domains were dichotomised into (0 for 0 values, 1 for all non-zero values). Logistic regression analysis was used to measure the association of these domains with the explanatory variables. Missing data occurred at very low frequency in the variables included in this study and occurred randomly. Multiple imputation was tested and the results showed little difference with and without imputation. Therefore, to keep the maximum number of the observations in the analysis, missing data was imputed using the simple random imputation method [13].

Results

A total of 1277 elderly participants were included in this study. Table 1 shows the unweighted frequency distribution and weighted percentage of the population for different sociodemographic factors, socioeconomic status and oral health status. No significant difference in mean OHIP-14 score was found for age, gender, marital status, education level, occupation and IMD. Having active caries, a PUFA score, pain related to teeth, active root caries, number of missing teeth and current smokers was associated with

significantly higher mean OHIP-14 scores. Mean scores for OHIP-14 and its domains are presented in table 2. The mean(SE) weighted total OHIP-14 score was 2.95 (0.17). Among the domains, pain had the highest and social disability the lowest mean score.

The results from the multivariate Zero-inflated Poisson regression analysis are presented in table 3. People with higher age and higher education level (degree and above) were significantly associated with lower OHIP-14 score. Gender was not significantly associated with OHIP-14. People with intermediate and manual occupations had significantly higher OHIP-14 score than professionals, however; unemployed people did not have significantly higher OHIP-14 than professionals. IMD was significantly associated with OHIP-14, where more deprived people had higher OHIP-14 scores than less deprived people (except quintile 3). People with an active dental caries or a PUFA score or pain related to teeth had significantly higher OHIP-14 scores than people with no active caries or PUFA score or pain related to teeth. Number of missing teeth or having an active root caries was negatively associated with OHIP-14 score. Wearing a denture was associated with higher OHIP-14 scores. “Current smokers” had significantly higher OHIP-14 scores compared with “never smokers”, while “past smokers” had similar OHIP-14 scores as “never smokers”. Self-reported general health was positively associated with OHIP-14, participants with poor/very poor self-reported general health had higher OHIP-14 score. Having a periodontal pocket, a bleeding site, anterior tooth wear and having systemic diseases were not associated with OHIP-14.

Table 4 shows the results of the multivariate logistic regression analysis for OHIP-14 domains. People who wear a denture have 2.5 times greater functional limitation than people who don't wear a denture. Self-reported general health was also significantly associated with functional limitation. People with poor/very poor self-reported general health had 2.3 times higher oral health functional limitation than the participants with very good/good self-reported general health. The pain domain was associated with pain related to teeth, systemic problems and self-reported health issues. People with systemic problems had a 44% greater chance

of experiencing psychological discomfort than people with no systemic problem. More deprived people had significantly higher discomfort scores compared to less deprived people, however most deprived people didn't have significantly higher odds for discomfort. However, having pain related to teeth, active root caries and systemic problems were associated with higher odds of discomfort. People wearing a denture have double the chances of experiencing discomfort.

Denture wearers, current smokers and people with poor self-perceived general health had higher odds of reporting physical disability. All other variables had no relationship with the physical disability domain. People with pain related to their teeth or dentures had a 2 times higher chance of having psychological disability. The presence of a systemic problem was also significantly associated with higher odds of psychological disability. Social disability was associated with active caries and pain related to the teeth. People with active caries have more than 2 times higher odds of having social disability. Having pain related to teeth was associated with a three-fold increase in social disability. Occupation was associated with handicap and pain related to teeth. People with an intermediate or manual occupation experienced twice as much handicap as people with a professional occupation. However unemployed people did not have significantly higher odds for handicap than people with a professional occupation.

Discussion

The relationship between clinical oral health status and oral health related quality of life was explored in a large and demographically diverse group of older adults resident in the United Kingdom. The presence of active caries or active oral disease (as assessed by the PUFA score and pain originating from the teeth) or wearing a denture predicted greater impact on OHRQoL. Conversely, indices of periodontal health (having periodontal pocket ≥ 4 mm or periodontal bleeding) had no impact on OHRQoL of elderly people.

Overall Oral Health Related Quality of Life

It is perhaps unsurprising that the presence of active oral disease including active caries has an impact on quality of life, particularly the experience of pain. The experience of pain affects the ability to perform many different physical activities [14]. This study found that the impact of pain originating from the teeth extends further and causes physical, psychological and social disability thus leading to a degree of handicap amongst older people. Therefore, it is important to reorient oral health services for the elderly to eliminate or prevent pain [15].

There was little relationship within the population sampled between markers of periodontal disease and oral health related quality of life. This may relate to the illness perceptions of the older age group, in that they may not interpret the symptoms of periodontal disease as requiring intervention, particularly in the absence of acute pain [16]. Tooth loss in this study was associated with poorer OHRQoL when the number of missing teeth was between 6 and 17, but not at higher levels of number of missing teeth. The theory of response shift may explain why the elderly population may report fewer impacts with more extensive numbers of missing teeth [17, 18]. Response shift refers to changes within people regarding their internal standards, values, or conceptualization of HRQOL over time and as a result of the experience of ill health [17]. As individuals age, they are more likely to consider minor or even severe oral health problems as insignificant at this point in their lives [18]. As a result people often express greater satisfaction with their oral health probably as the result of lower expectations [18]. Additionally, older people may ascribe a lower priority to oral health in comparison to general health and thus report less impact of their oral health than general health on QoL [14].

Oral Health related QoL reduces with age and is related to social class. People aged 75 years or above had lower oral health related quality of life than people aged 65-75 years old. Previous studies have reported similar results, the oral health of pre-seniors was better than that of seniors [18]. Elderly people of low socio-economic status reported significantly higher impact on OHRQoL, in contrast to previous research in German and Israeli populations [15, 19]. However, it agrees with data from younger populations [20]. This has implications for needs assessment and oral health care service planning.

In the present study, wearing a denture was a strong independent predictor of poor OHRQOL. This agrees with the findings of previous studies [21, 22]. There are many possible reasons for the association of dentures with poor oral health related quality of life including the quality of the prostheses (e.g., adaptation and retention) [23]. Improperly fitted prosthesis or dentures can cause stomatitis and traumatic ulcer. Appropriate care of prostheses is essential to avoid oral health-related impediments to well-being [24].

This study found strong association of OHRQoL with self-reported general health. People with poor self-reported general health also had a significantly higher impact on their OHRQoL, highlighting the role of oral health as an integral part of general health and essential to well-being and the close link between general and dental health [25].

Domains of Oral Health Related Quality of Life

No clear pattern of relationships emerged between the experience of oral disease and the individual domains of oral health related quality of life. However, there were some variables that appeared as significant in at least three analyses. Wearing a denture was associated with functional limitation, psychological discomfort and physical discomfort. The experience of pain related to the teeth was related to psychological discomfort, physical discomfort, social disability and handicap, supporting previous research which has identified this as a key determinant of impact on quality of life (26).

The advantage of a large national dataset is that it allows for the understanding of the impact of disease independent of treatment seeking behaviour. Much of the research exploring the impact of oral disease on oral health related quality of life has involved samples drawn from care settings [26-29], which does not represent those who experience symptoms but do not seek help. Perceptions of the necessity of intervention are also likely to relate to the perception of impact, since disruption of daily activities is likely to act as a trigger to attendance.

The findings from the present study suggest that where active caries is present, and/or ulcers, fistulae or abscesses then this is likely to impact on oral health related quality of life. While preventive strategies are likely to reduce such manifestations in the long term [2], given the cohort effects, it is likely that there will be a continued need for screening and treatment amongst older people in order to reduce the burden of oral disease.

Conclusion

Whereas previous research has suggested a moderate relationship between oral disease and quality of life in this large scale survey of older adults, the presence of active caries and the presence of one or more of the PUFA indicators are associated with impaired oral health related quality of life in older adults, but not indicators of periodontal status. The implication of this is that whilst focussing on prevention of disease, there is an ongoing need for oral health screening and treatment in this group.

Conflicts of interest

No conflict of interest

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Table 1: Descriptive analysis of the characteristics of elderly in UK (n=1277)

	n(%)	Total OHIP-14
	n=1277	Weighted Mean(SE)
Age		
65-75	805 (59.1)	3.12(0.23)
75 and above	472 (40.8)	2.69(0.24)
Gender		
Male	627 (47.6)	2.73(0.21)
Female	650 (52.4)	3.14(0.26)
Marital Status		
Never married	79 (7.3)	2.53(0.48)
Married	811 (57.6)	2.72(0.19)
Previously married	386 (35.1)	3.47(0.35)
Education		
No qualification	587 (47.5)	3.34(0.27)
Below degree	482 (36.9)	2.73(0.27)
Degree or above	207 (15.5)	2.23(0.31)
NSSEC		
Professional	430 (30.8)	2.42(0.24)
Intermediate	305 (24.6)	3.19(0.38)
Manual	430 (34.6)	3.21(0.30)
Unemployed	111 (10.0)	3.03(0.63)
IMD		
Quintile 1	127(11.3)	3.06(0.49)
Quintile 2	182(14.6)	3.90(0.60)
Quintile 3	285(22.8)	2.78(0.30)
Quintile 4	326(24.2)	2.82(0.39)

Quintile 5	355(27.1)	2.62(0.32)
Active caries		
No	893 (68.5)	2.57(0.18)
Yes	382 (31.5)	3.76(0.36)*
At least one pocket $\geq 4\text{mm}$		
No	512 (37.9)	2.83(0.28)
Yesj	740 (52.1)	2.92(0.21)
At least one PUFA		
No	1185 (92.7)	2.69(0.15)
Yes	90 (7.3)	6.21 (1.11)*
Pain related to teeth		
No	1205(94.6)	2.68(0.16)
Yes	70(5.4)	7.61(1.21)*
Active root caries		
No	1116 (85.9)	2.80(0.18)
Yes	159 (14.1)	3.87(0.50)*
Anterior tooth wear		
No	105 (7.8)	3.87(0.79)
Yes	1190 (92.2)	2.87(0.17)
At least one bleeding site		
No	627 (47.6)	2.74(5.02)
Yes	638 (52.4)	3.05(5.52)
Number of missing teeth		
0-5	192 (15.5)	2.87(0.56)
6-11	482 (36.0)	2.02(0.23)
12-17	289 (23.1)	2.91(0.28)
18-23	170 (13.2)	3.58(0.40)

24-32	144 (12.2)	5.15(0.66)*
Wearing Denture		
No	735 (57.1)	2.32(0.22)
Yes	540 (42.9)	3.78(0.26)*
Smoking status		
Never	535 (41.3)	2.83(0.28)
Past	650 (51.0)	2.78(0.21)
Current	92 (7.7)	4.64(0.85)*
Systemic Problem		
No	572 (43.6)	2.16(0.22)
Yes	703 (56.4)	3.55(0.24)*
Self-reported general health		
Very good/good	922 (70.1)	2.21(0.15)
Fair	272 (22.4)	4.54(0.47)
Poor/very poor	83 (6.6)	5.44(0.90)*

* p-value \leq 0.05; Mann Whitney U test and Kruskal Wallis test were used as appropriate

Table 2: mean OHIP-14 and its domains in UK elderly population (n-1277)

	Unweighted			Weighted	
	Mean(SD)	Median (IQR)	Potential range of values	Mean(SE)	Median (IQR)
Total OHIP-14	2.94(5.33)	1.0(4.0)	1-56	2.95(0.17)	1.0(4.0)
Functional Limitation	1.25(0.75)	1.0(0.0)	1-8	1.25(0.02)	1.0(0.0)
Pain	1.84(1.11)	1.0(2.0)	1-8	1.82(0.03)	1.0(2.0)
Discomfort	1.48(1.00)	1.0(0.0)	1-8	1.48(0.03)	1.0(0.0)
Physical Disability	1.22(0.68)	1.0(0.0)	1-8	1.23(0.02)	1.0(0.0)
Psychological Disability	1.28(0.75)	1.0(0.0)	1-8	1.29(0.2)	1.0(0.0)
Social Disability	1.08(0.40)	1.0(0.0)	1-8	1.09(0.13)	1.0(0.0)
Handicap	1.13(0.53)	1.0(0.0)	1-8	1.13(0.02)	1.0(0.0)

Table 3: Bivariate and Multivariate linear regression analysis of determinants of OHIP-14 domains in UK elderly population.

	Bivariate	Multivariate
	Poisson	Poisson
	IRR(95%CI)	IRR(95%CI)
Age		
65-75	1.00 (Reference)	1.00 (Reference)
75 and above	1.05(0.98;1.12)	0.90(0.83;0.97)*
Gender		
Male	1.00 (Reference)	1.00 (Reference)
Female	1.13(1.07;1.22)*	1.07(0.99;1.16)
Marital Status		
Never married	1.00 (Reference)	1.00 (Reference)
Married	1.10(0.95;1.27)	1.14(0.98;1.33)
Previously married	1.33(1.15;1.55)*	1.27(1.08;1.48)*
Education		
No qualification	1.00 (Reference)	1.00 (Reference)
Below degree	0.82(0.77;0.88)*	0.95(0.88;1.05)
Degree or above	0.66(0.60;0.73)*	0.78(0.69;0.89)*
NSSEC		
Professional	1.00 (Reference)	1.00 (Reference)
Intermediate	1.12(1.13;1.35)*	1.15(1.04;1.26)*
Manual	1.28(1.18;1.38)*	1.11(1.01;1.21)*
Unemployed	1.39(1.22;1.58)*	1.10(0.97;1.28)
IMD		
Quintile 1 (Wealthiest)	1.00 (Reference)	1.00 (Reference)

Quintile 2	1.08(0.95;1.22)	1.15(1.01;1.32)*
Quintile 3	0.92(0.81;1.04)	1.07(0.93;1.23)
Quintile 4	0.94(0.83;1.06)	1.21(1.06;1.39)*
Quintile 5 (Poorest)	0.87(0.77;0.98)*	1.21(1.06;1.39)*
Active caries		
No	1.00 (Reference)	1.00 (Reference)
Yes	1.34(1.25;1.43)*	1.37(1.25;1.50)*
At least one pocket $\geq 4\text{mm}$		
No	1.00 (Reference)	1.00 (Reference)
Yes	1.02(0.96;1.09)	1.03(0.96;1.11)
At least one PUFA		
No	1.00 (Reference)	1.00 (Reference)
Yes	1.53(1.39;1.68)*	1.17(1.05;1.31)*
Pain related to teeth		
No	1.00 (Reference)	1.00 (Reference)
Yes	1.43(1.31;1.58)*	1.34(1.20;1.50)*
Active root caries		
No	1.00 (Reference)	1.00 (Reference)
Yes	1.17(1.17;1.27)*	0.87(0.78;0.98)*
Anterior tooth wear		
No	1.00 (Reference)	1.00 (Reference)
Yes	0.81(0.73;0.90)*	1.00(0.87;1.12)
At least one bleeding site		
No	1.00 (Reference)	1.00 (Reference)
Yes	1.06(0.99;1.15)	1.03(0.96;1.11)
Number of missing teeth		
0-5	1.00 (Reference)	1.00 (Reference)

6-11	0.87(0.78;0.97)*	0.77(0.69;0.87)*
12-17	1.16(1.03;1.29)*	0.85(0.73;0.97)*
18-23	1.31(1.16;1.48)*	0.88(0.74;1.02)
24-32	1.56(1.39;1.75)*	1.11(0.93;1.30)
Wearing Denture		
No	1.00 (Reference)	1.00 (Reference)
Yes	1.42(1.33;1.51)*	1.30(1.17;1.44)*
Smoking status		
Never	1.00 (Reference)	1.00 (Reference)
Past	0.91(0.85;0.97)	0.86(0.80;0.93)
Current	1.39(1.25;1.54)*	1.19(1.07;1.34)*
Systemic Problem		
No	1.00 (Reference)	1.00 (Reference)
Yes	1.27(1.18;1.26)*	1.07(0.99;1.16)
Self-reported general health		
Very good/good	1.00 (Reference)	1.00 (Reference)
Fair	1.41(1.32;1.52)*	1.20(1.11;1.31)*
Poor/very poor	1.64(1.47;1.81)*	1.29(1.14;1.46)*

*p-value ≤ 0.05

Table 4: Multivariate linear regression analysis of determinants of domains of OHIP-14 in UK elderly population.

	Functional Limitation	Pain	Psychological Discomfort	Physical Disability	Psychological Disability	Social Disability	Handicap
Age							
65-75	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
75 and above	0.89(0.54;1.20)	0.79(0.61;1.03)	0.54(0.38;0.75)*	0.93(0.61;1.42)	0.72(0.45;1.05)	0.56(0.29;1.07)	0.89(0.52;1.49)
Gender							
Male	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Female	0.71(0.48;1.04)	1.09(0.84;1.41)	1.33(0.97;1.82)	0.73(0.48;1.10)	1.22(0.85;1.75)	1.16(0.65;2.09)	0.65(0.39;1.08)
Marital Status							
Never married	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Married	1.18(0.55;2.86)	1.06(0.63;1.79)	0.71(0.39;1.34)	0.91(0.43;2.10)	1.03(0.50;2.16)	0.59(0.29;1.26)	0.78(0.33;2.08)
Previously married	1.06(0.47;2.65)	1.12(0.65;1.93)	1.07(0.58;2.05)	0.99(0.45;2.33)	1.40(0.69;3.08)	0.55(0.20;1.73)	1.11(0.45;3.03)
Education							
No qualification	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Below degree	0.98(0.63;1.46)	1.18(0.90;1.57)	0.94(0.67;1.33)	1.25(0.81;1.93)	0.95(0.65;1.40)	0.75(0.39;1.41)	1.42(0.82;2.42)
Degree or above	0.70(0.35;1.33)	0.95(0.63;1.43)	1.54(0.94;2.51)	1.24(0.61;2.45)	1.09(0.60;1.95)	0.82(0.31;1.98)	1.45(0.62;3.25)
NSSEC							
Professional	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Intermediate	0.89(0.51;1.51)	1.20(0.86;1.67)	1.28(0.85;1.94)	1.84(1.04;3.25)*	1.16(0.71;1.88)	1.56(0.73;3.40)	2.52(1.28;5.08)*
Manual	1.07(0.66;1.75)	0.92(0.66;1.28)	1.42(0.95;2.13)	2.11(1.25;3.65)*	1.45(0.92;2.31)	1.10(0.50;2.44)	2.09(1.07;4.20)*
Unemployed	1.01(0.47;2.05)	0.77(0.47;1.22)	0.84(0.44;1.52)	1.87(0.84;3.94)	1.17(0.59;2.23)	1.72(0.61;4.47)	1.19(0.36;3.25)
IMD							

Quintile 1	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Quintile 2	1.93(0.92;4.19)	1.52(0.93;2.51)	1.85(1.01;3.45)*	1.99(0.94;4.38)	1.53(0.81;2.95)	1.68(0.48;6.77)	1.37(0.56;3.47)
Quintile 3	1.63(0.81;3.46)	1.24(0.77;1.97)	1.65(0.93;2.97)	1.75(0.86;3.70)	1.08(0.57;2.04)	2.62(0.89;9.64)	1.39(0.62;3.35)
Quintile 4	1.86(0.92;3.94)	1.15(0.72;1.84)	2.01(1.14;3.62)*	1.68(0.82;3.60)	1.34(0.73;2.53)	2.29(0.77;8.50)	1.16(0.49;2.87)
Quintile 5	1.50(0.73;3.25)	1.18(0.74;1.89)	1.56(0.87;2.87)	1.48(0.70;3.25)	1.01(0.54;1.94)	1.93(0.62;7.43)	0.91(0.37;2.34)
Active caries							
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	1.37(0.85;2.17)	1.00(0.72;1.39)	1.05(0.70;1.55)	1.05(0.70;1.55)	1.32(0.84;2.03)	2.21(1.16;4.12)*	1.60(0.83;2.84)
At least one pocket ≥4mm							
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	1.16(0.79;1.73)	1.01(0.78;1.30)	1.13(0.82;1.54)	1.13(0.82;1.54)	1.06(0.74;1.52)	1.21(0.68;2.21)	0.92(0.56;1.52)
At least one PUFA							
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	1.56(0.80;2.93)	1.17(1.05;1.31)	1.20(0.68;2.08)	0.92(0.42;1.90)	1.06(0.53;1.92)	1.09(0.40;2.63)	1.07(0.44;2.35)
Pain related to teeth							
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	2.01(0.99;3.89)	5.75(3.11;11.35)*	1.95(1.08;3.47)*	2.26(1.08;4.48)*	2.41(1.28;4.40)*	3.26(1.37;7.21)*	4.01(1.84;8.33)*
Active root caries							
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	0.87(0.47;1.59)	0.87(0.78;1.98)	1.71(1.04;2.83)*	0.68(0.34;1.33)	1.47(0.85;2.54)	0.50(0.18;1.23)	0.86(0.40;1.80)
Anterior tooth wear							
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	0.82(0.44;1.60)	0.99(0.87;1.12)	1.43(0.81;2.64)	1.07(0.54;2.24)	1.02(0.56;2.01)	1.25(0.46;4.46)	0.92(0.41;2.38)
At least one bleeding site							

No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	0.78(0.53;1.15)	1.07(0.83;1.38)	0.95(0.70;1.30)	1.05(0.70;1.58)	1.20(0.84;1.70)	0.99(0.56;1.77)	0.93(0.57;1.53)
Number of missing teeth							
0-5	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
6-11	1.04(0.53;2.14)	0.75(0.52;1.09)	1.04(0.63;1.73)	0.57(0.29;1.12)	0.64(0.37;1.15)	0.50(0.10;1.65)	1.26(0.78;0.97)
12-17	1.25(0.57;2.85)	0.81(0.51;1.29)	1.33(0.74;2.41)	0.58(0.26;1.31)	0.93(0.48;1.81)	0.74(0.32;2.15)	0.82(0.03;1.29)
18-23	1.11(0.45;2.78)	1.01(0.57;1.77)	1.06(0.52;2.13)	0.88(0.36;2.17)	0.71(0.32;1.56)	1.07(0.30;3.75)	1.60(0.16;1.48)
24-32	1.52(0.60;3.90)	1.13(0.61;2.07)	0.98(0.46;2.07)	0.97(0.38;2.45)	0.77(0.33;1.76)	1.31(0.33;4.93)	2.00(0.39;1.75)
Wearing Denture							
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	2.56(1.50;4.40)*	1.31(0.92;1.85)	2.25(1.50;3.42)*	2.79(1.57;5.03)*	2.03(1.26;3.29)*	1.23(0.54;2.80)	1.72(0.85;3.52)
Smoking status							
Never	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Past	1.18(0.79;1.77)	1.06(0.82;1.37)	1.08(0.78;1.48)	1.01(0.66;1.55)	1.04(0.72;1.50)	0.80(0.44;1.48)	0.83(0.50;1.40)
Current	0.97(0.47;1.92)	1.13(0.69;1.85)	1.44(1.83;2.45)*	2.12(1.11;3.99)*	1.48(0.80;2.66)	1.84(0.74;4.30)	0.81(0.32;1.83)
Systemic Problem							
No	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Yes	0.95(0.62;1.45)	1.44(1.11;1.87)*	1.28(0.92;1.78)	1.47(0.94;2.31)	1.54(1.05;2.26)*	1.62(0.88;3.20)	1.30(0.76;2.26)
Self-reported general health							
Very good/good	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Fair	1.74(1.11;2.72)*	1.45(1.06;1.98)*	1.72(1.19;2.48)*	1.84(1.17;2.90)*	1.45(0.96;1.15)	1.20(0.61;2.27)	1.57(0.88;2.76)
Poor/very poor	2.32(1.18;4.41)*	1.16(0.69;1.41)	1.97(1.11;3.47)*	3.10(1.62;5.84)*	1.37(0.71;2.55)	0.50(0.10;1.65)	1.90(0.78;4.34)

*p-value \leq 0.05